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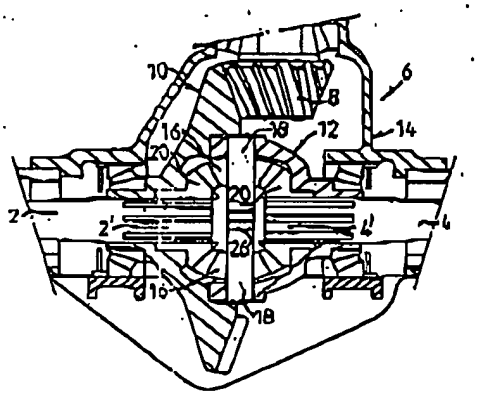
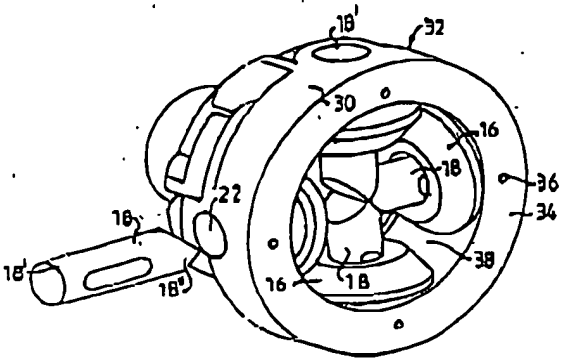
(54) Title: DIFFERENTIAL GEAR





(57) Abstract: Differential gear in which a pinion (8) is in driving engagement with a crown wheel (10) fastened to the outside of a differential housing (12) containing differential pinions (16) which are carried by spigots (18) fastened in the differential housing and are in driving engagement with driveshaft pinions (20) fastened to the ends (which are situated inside the differential housing) of a pair of coaxial wheel driveshafts (2, 4). Each differential pinion (16) is carried by a separate differential spigot (18) of its own which has an outer first end accommodated in a positionally fixed manner in the differential housing (which takes the form of an undivided housing unit) and an inner second end supported and positionally fixed at the centre of the differential housing. The differential housing contains four differential pinions (16) supported by four separate differential spigots (18) which are fitted in a common transverse plane to the differential housing and are mutually aligned to form a right-angled differential spigot cross. The inner ends (18") of the differential spigots are wedge-shaped with a 90° leading edge angle between the leading edge surfaces forming the wedge tip (26), and the wedge-shaped inner ends of the spigots are closely in way of one another so that they lock one another firmly.

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Differential gear

The present invention relates to a differential gear of the kind indicated in the preamble to patent claim 1.

State of the art

Heavy-duty motor vehicles such as trucks usually have on the rear axle a gear unit consisting of a set of gears, preferably in the form of a differential gear, combined with a final gear. Such a differential gear generally consists of a simple type of planetary gear whose function is not only to allow the powered wheels at the ends of the wheel driveshafts to rotate at different speeds (as required when negotiating a bend) but also to make it possible for the drive power to be distributed equally to the two powered wheels.

In cases where the powered wheels are the vehicle's rear wheels, the differential gear has a differential housing which is supported for rotation relative to the shaft casings of the driveshafts of the rear wheels and which is provided on the outside with a gearwheel (crown wheel) driven by the propeller shaft via a pinion.

The differential housing incorporates at least two, but on heavy trucks always four, differential pinions (planet wheels) which are supported for rotation on a common differential spider and are in driving engagement with driveshaft pinions (sun wheels) fastened to the ends (which are situated inside the differential housing) of the rear axle's two wheel driveshafts.

The differential housing is generally composed of two halves to make it easy to fit the gearwheels (pinions) inside it. The outside of the differential housing is provided with a machined flange to which the annular crown wheel is applied and fastened.

As mentioned above, the differential pinions are usually carried by a common differential spider made in the form of an undivided unit. The differential spider is then usually

clamped or fixed between the two halves of the differential housing, which are held together by threaded connections.

Also known is an alternative design solution (Mercedes Benz) whereby the aforesaid undivided differential spider is replaced by a differential shaft which runs diametrically across the inside of the differential housing, carries two of the differential pinions and is provided at its midpoint with a pair of recesses situated on opposite sides of the differential shaft. These two recesses accommodate the ends of a pair of differential spigots, in way perpendicularly of the differential shaft, for each of the other two differential pinions within the differential housing.

Object of the invention

The prime object of the present invention is to provide a differential gear whose housing is so designed that there is no need for a dividing plane in the transverse plane region where the spigot ends of the differential spider are fastened or accommodated. In other words, the object is to make it possible to fit the various constituent elements of the differential spider into the differential housing without difficulty despite there being no dividing plane in the fastening region concerned.

Description of the invention

According to the invention, the aforesaid object is achieved in a differential gear of the kind indicated in the preamble to patent claim 1 by each differential pinion being carried by a separate differential spigot of its own and each spigot having an outer first end accommodated in the differential housing in a positionally fixed manner and an inner second end supported and positionally fixed at the centre of the differential housing.

When the differential gear is in operation and drive power is thus being transmitted from the crown wheel to the wheel driveshafts, the differential spigots will be subject to flexural loading (bending moments and power effects) caused by forces from the

differential pinions, so each differential spigot will need support both in a wall portion of the surrounding differential housing and at the centre of the differential housing.

In addition to the features indicated in the characterising part of patent claim 1, the differential gear according to the invention may also exhibit the features indicated in claims 2-8.

Particularly in the case of a heavy-duty truck, the differential housing preferably contains four differential pinions which are then carried by four separate differential spigots. These differential spigots are fitted in a common transverse plane to the differential housing and are mutually aligned to form a right-angled differential spider. In this case the differential spider is made up of four separate differential spigots.

The inner ends of the differential spigots (at the centre of the space inside the differential housing) are advantageously wedge-shaped with 90° leading edge angles between the leading edge surfaces forming the wedge tips, and the wedge-shaped inner ends of the spigots are closely in way of one another so that their parallel wedge tips coincide along a line which is coaxial or parallel with the wheel driveshafts.

The differential housing of a differential gear according to the invention may thus with advantage take the form of an undivided housing unit with no dividing plane at all in the region of the transverse plane in which the differential spigots are fitted.

To keep the differential spigots in position-fixing engagement by shape with one another at their inner ends when the differential gear is in operation and drive power is being transmitted from the crown wheel to the wheel driveshafts, it is advantageous that at their outer ends and in their respective longitudinal directions the differential spigots be supported against an annular contact surface. This force-absorbing contact surface may advantageously be provided on the gearwheel which takes the form of a crown wheel and is firmly arranged on the outside of the differential housing. This provides a kind of locking or positional fixing of the differential spigots. The result is "interception" of the

axial force which arises from their cooperating 90° wedge tips and which endeavours to move the differential spigots in their longitudinal direction outwards from the centre of the differential housing. The locking or positional fixing of the differential spigots is therefore advantageously integrated in the crown wheel, which thus acts as a kind of locking socket which prevents the outer ends of the differential spigots from moving radially outwards.

The differential housing incorporates advantageously a housing portion which surrounds the differential pinions in an annular manner and which has radially oriented accommodating apertures in which the outer ends of the differential spigots are held in position by said locking when the spigots engage with and lock one another mutually at their inner ends.

The housing portion surrounding the differential pinions has advantageously at a distance from the apertures which accommodate the spigots an annular delineating surface situated in a transverse plane perpendicular to the longitudinal direction of the wheel driveshafts. The gearwheel which thus takes the form of a crown wheel has advantageously a corresponding annular fastening surface intended to be applied to said delineating surface of the housing portion in order to fasten the crown wheel to the housing portion, e.g. by threaded connections through these two annular surfaces abutting against one another.

The housing portion surrounding the differential pinions may advantageously have a spherically curved inside which faces the radially outward-facing rear sides of the differential pinions and which thereby provides supporting reaction surfaces to absorb the forces which urge the differential pinions radially outwards in the longitudinal direction of the differential spigots.

Brief description of the drawings

The invention will now be illustrated and explained further with reference to an embodiment depicted in the attached drawings, which are as follows:

Fig. 1 depicts a horizontal section through a differential gear of the kind which the invention refers to;

Fig. 2 depicts in perspective a differential housing, provided with a crown wheel, for a differential gear according to the invention;

Fig. 3 depicts separately, in perspective, only the differential housing depicted in Fig. 2 with the crown wheel applied;

Fig. 4 depicts in perspective the positioning of the differential spider supporting the planet wheels, but without, for the sake of clarity, the surrounding differential housing;

Fig. 5 depicts on a larger scale the differential spider according to Fig. 4, but with one differential spigot omitted;

Fig. 6 depicts the same region as in Fig. 5, but with only one differential spigot in a notional functional position with its differential pinion (planet wheel) in driving engagement with a driveshaft pinion (sun wheel), with the driveshaft omitted;

Fig. 7 depicts the housing of the differential gear in the same sectional view as in Fig. 1; and

Fig. 8 depicts in diametral cross-section the differential housing according to Fig. 7 and therefore corresponds to the differential housing according to Fig. 3 viewed in diametral cross-section.

Description of an embodiment

Fig. 1 depicts the central region of a rear axle for a vehicle with rear wheel drive. The rear axle, which incorporates two wheel driveshafts (halfshafts) 2, 4, is combined in a conventional manner with a rear axle gear (final gear) which includes a differential gear 6. The drive power from the vehicle's engine (not depicted) is transmitted via a propeller shaft (not depicted) and a pinion 8 associated therewith to a crown wheel 10 which is

attached firmly (advantageously by threaded connections) to the outside of a differential housing 12. This differential housing is supported for rotation in a final gear casing 14 which is itself joined to shaft casings which enclose the wheel driveshafts 2, 4.

As mostly clearly indicated by Figs. 3-4, the differential housing 12 contains four differential pinions 16 carried by (see Fig. 3 in particular) differential spigots 18 fastened in the differential housing. The four differential pinions 16 are also in driving engagement with driveshaft pinions 20 which are fastened to the ends 2', 4' (see Fig. 1), situated inside the differential housing 12, of the coaxial wheel driveshafts 2, 4.

As probably indicated with the desired clarity by Figs. 2-5, the primary distinguishing feature of the invention is that each differential pinion 16 is carried by a separate differential spigot 18 of its own. Each such differential spigot 18 has an outer first end 18' accommodated in a positionally fixed manner in a radially directed fitting hole 22 in the differential housing 12, and an inner second end 18" supported and positionally fixed at the centre of the differential housing (see Figs. 3, 4 and 5 in particular).

The four differential spigots 18, which are thus fitted and situated in a common transverse plane to the differential housing 12, are mutually aligned (see Figs. 3-4 in particular) so as to form a right-angled differential spigot cross.

The mutual positional fixing of the differential spigots 18 at the centre of the differential housing is achieved by their inner ends 18" being made wedge-shaped with a 90° leading edge angle between the planar leading edge surfaces 24', 24" forming a wedge tip 26 (see Fig. 6). As clearly indicated by Figs. 3-5, the differential spigots 18 are closely in way of one another via their thus wedge-shaped inner ends 18" so that their parallel wedge tips 26 coincide along a line parallel with the centreline of the coaxial wheel driveshafts 2, 4.

As most clearly indicated by Fig. 3, the differential housing 12 takes the form of an undivided housing unit which has no dividing plane in the region of the transverse plane in which the differential spigots 18 are fitted. As particularly clearly indicated by Figs. 2-

3, the differential spigots 18 are held in position-fixing engagement by shape with one another at their inner ends 18" by the fact that they bear at their outer ends 18' and in their respective longitudinal directions against an annular contact surface 28 (see Figs. 4-5) on the crown wheel 10 fastened to the outside of the differential housing 12. The internal contact surface 28 of the crown wheel 10 thus abuts, when the differential housing 12 and the crown wheel 10 are fitted together, against the cylindrical outside 30 of the housing portion 32 which surrounds the differential pinions 16 in an annular manner and which accommodates the radially directed spigot fastening holes 22.

As indicated by Fig. 3, the housing portion 32 surrounding the differential pinions 16 has at a distance from the accommodating apertures 22 a planar annular delineating surface 34 situated in a transverse plane perpendicular to the longitudinal direction of the wheel driveshafts 2, 4. The crown wheel 10 has a corresponding planar annular fastening surface which allows close fastening of the crown wheel to the delineating surface 34 of the housing portion 32. The delineating surface 34 accommodates for the purpose four fastening holes 36 for fastening screws.

As also indicated by Fig. 3, the housing portion 32 surrounding the differential pinions 16 is provided with a spherically curved concave inside 38 facing the differential pinions' likewise spherical but convex rear sides 40 facing radially outwards. The spherically curved inside 36 of the housing portion 32 provides supporting reaction surfaces to accommodate the forces which act upon the differential pinions 16 in the longitudinal direction of the differential spigots 18.

Fig. 7 and Fig. 8 show in more detail the central portions of the housing 12 of the differential gear 6, depicted respectively in the same sectional view as in Fig. 1 and in the sectional plane VIII-VIII in Fig. 7.

Patent claims

1. Differential gear in which a driving gearwheel (8), e.g. a pinion, is in driving engagement with a gearwheel (10), e.g. a crown wheel, arranged firmly on the outside of a differential housing (12) containing differential pinions (16) which are carried by spigots (18) fastened in the differential housing and are in driving engagement with driveshaft pinions (20) fastened to the ends (2', 4') (which are situated inside the differential housing) of a pair of coaxial wheel driveshafts (2, 4'), characterised in that each differential pinion (16) is carried by a separate differential spigot (18) of its own and each spigot has an outer first end (18') accommodated in a positionally fixed manner in the differential housing (12) and an inner second end (18") supported and positionally fixed at the centre of the differential housing.

2. Differential gear according to claim 1, characterised in that the differential housing (12) contains four differential pinions (16) carried by four separate differential spigots (18) and these differential spigots are fitted in a common transverse plane to the differential housing and are mutually aligned to form a right-angled cross.

3. Differential gear according to claim 1 or 2, characterised in that the inner ends (18") of the differential spigots (18) are wedge-shaped with a 90° leading edge angle between the leading edge surfaces (24', 24") of the wedge tip (26), and the wedge-shaped inner ends of the spigots are closely in way of one another so that their parallel wedge tips (26) coincide along a line parallel with the wheel driveshafts (2, 4).

4. Differential gear according to claim 2 or 3, characterised in that the differential housing (12) takes the form of an undivided housing unit with no dividing plane in the region of the transverse plane in which the differential spigots (18) are fitted.

5. Differential gear according to any one of the foregoing claims, characterised in that the differential spigots (18) are held in position-fixing engagement by shape with one another at their inner ends (18") by the fact that at their outer ends (18') and in their

respective longitudinal directions they bear against an annular contact surface (28) on the gearwheel which takes the form of a crown wheel (10) and is arranged firmly on the outside of the differential housing.

6. Differential gear according to any one of the foregoing claims, characterised in that the differential housing (12) includes a housing portion (32) which surrounds the differential pinions in an annular manner and which has radially directed accommodating apertures (22) for fastening the outer ends (18') of the differential spigots.

7. Differential gear according to claim 6, characterised in that the housing portion (32) surrounding the differential pinions (16) has at a distance from the accommodating apertures (22) an annular delineating surface (34) situated in a transverse plane perpendicular to the longitudinal direction of the wheel driveshafts (2, 4) and that the gearwheel which takes the form of a crown wheel (10) has a fastening surface applied to this delineating surface.

8. Differential gear according to claim 6 or 7, characterised in that the housing portion (32) surrounding the differential pinions (16) has a spherically curved inside (38) facing the rear sides (40), which face radially outwards, of the differential pinions (16) in order to provide supporting reaction surfaces to absorb the forces which act upon the differential pinions in the longitudinal direction of the differential spigots (18).

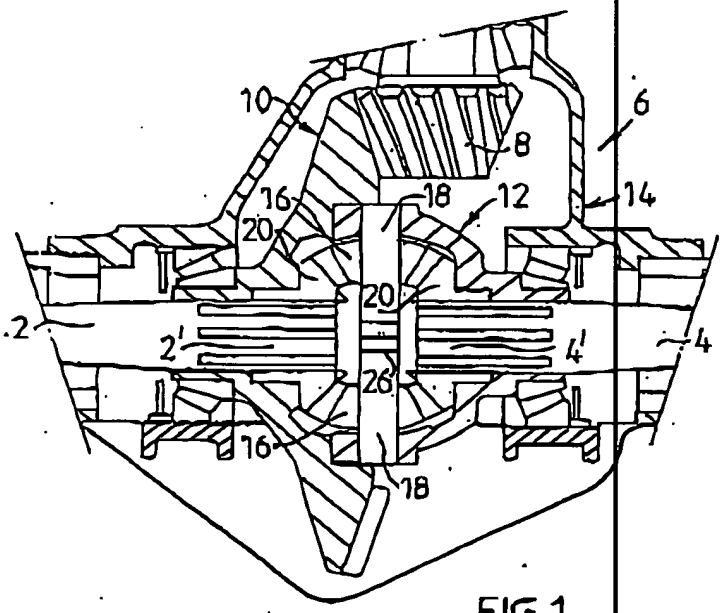

FIG.1

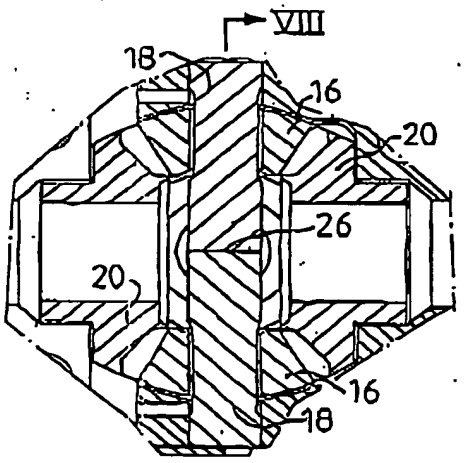

FIG.7

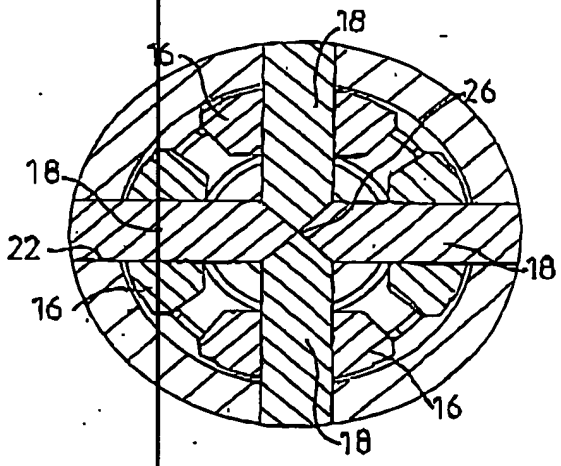

FIG.8

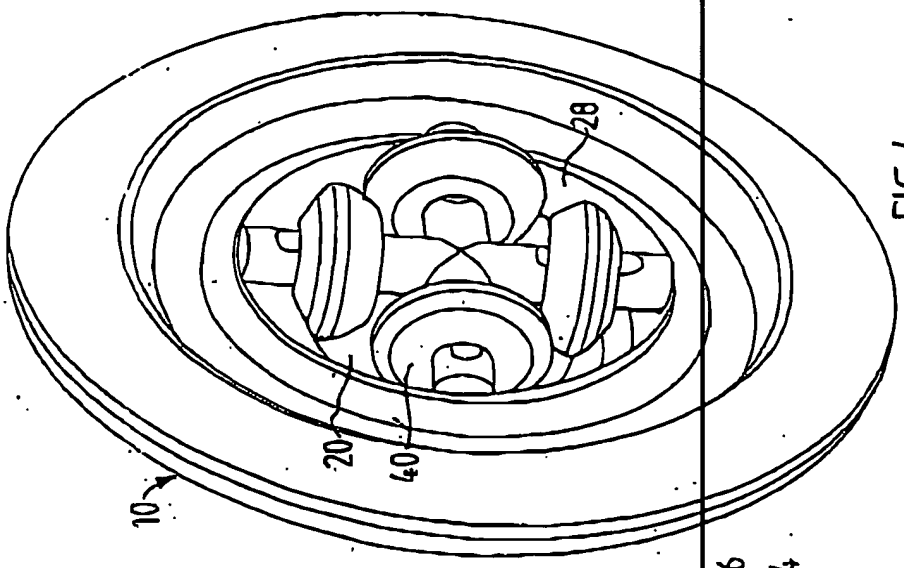

FIG.4

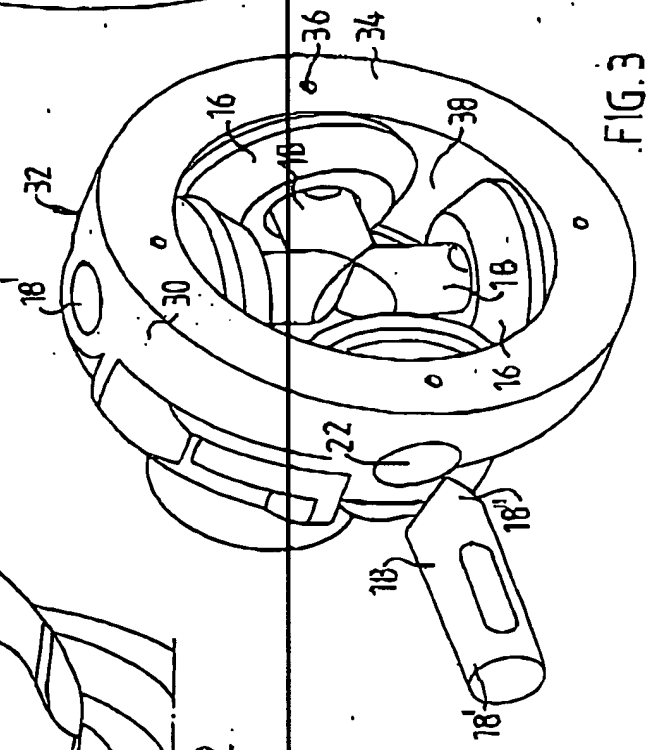

FIG.3

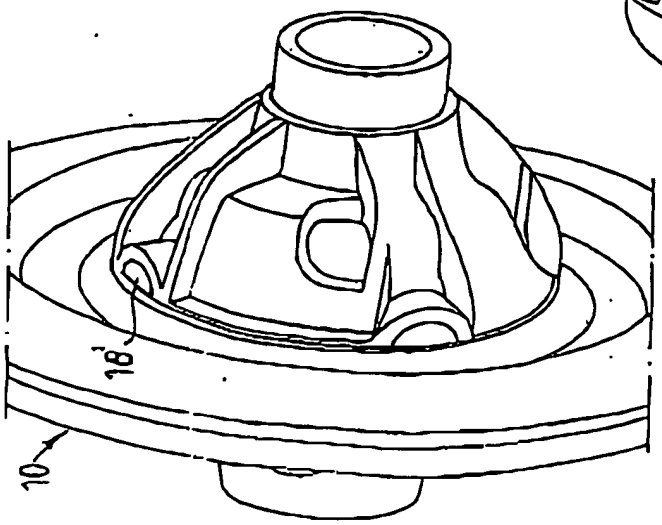

FIG.2

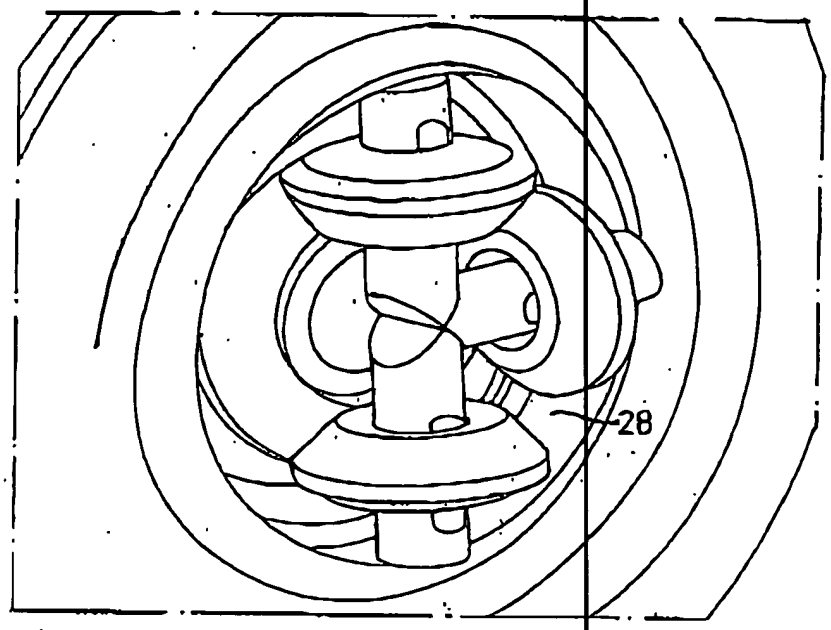

FIG.5

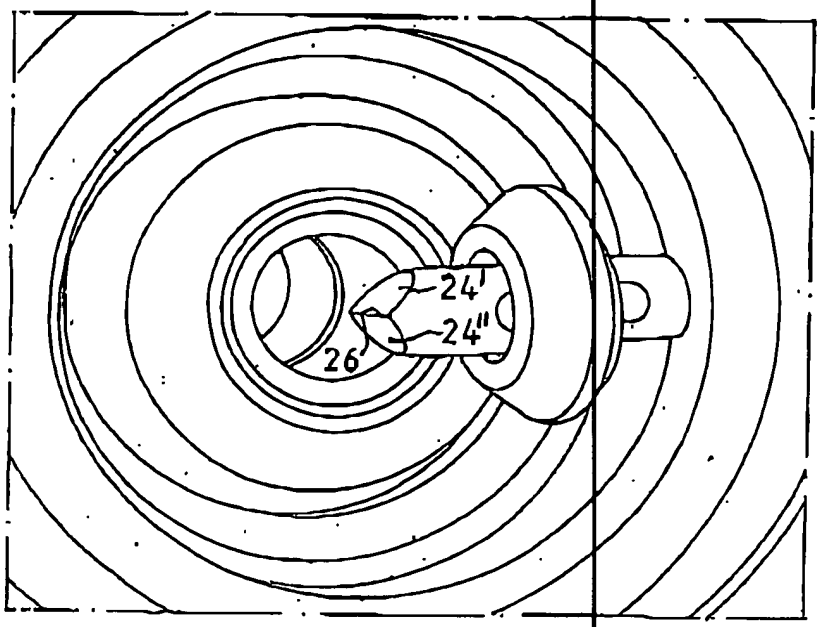

FIG.6

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 01/01071

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: F16H 48/08
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: F16H, B60K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3593595 A (J.I. CASE COMPANY), 20 July 1971 (20.07.71), column 1, line 39 - line 61, figures 2, 3a, description --	1,2,4,6-8
X	Derwent's abstract, No 97-478591/44, week 9744, ABSTRACT OF RU, 2076964 (Gaz. Stock Co), 10 April 1997 (10.04.97), abstract, figure 1 --	5
A	SE 459034 B (SAAB-SCANIA AB), 29 May 1989 (29.05.89), figure 2, abstract --	1-8
A	US 5647814 A (KRISHER), 15 July 1997 (15.07.97), figures 1-2, abstract --	1-8

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
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"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 August 2001	21-08-2001
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	Authorized officer Anna Salomonsson / JA A Telephone No. + 46 8 782 25 00

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INTERNATIONAL SEARCH REPORT

Information on patent family members

02/07/01

International application No.
PCT/SE 01/01071

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 3593595 A	20/07/71	NONE	
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